Monitoring Wetness of Strawberry Plants Using Color and Thermal Imaging for the Strawberry Advisory System (SAS)

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Summary

This study tried to find a better alternative to the widely used leaf wetness sensors. The task was to detect the presence of water on a given surface. To achieve that, computer vision and artificial intelligence (deep learning) methods were used using color and thermal imaging. The results from both methods were compared with manual observation and with sensor readings. The artificial intelligence method using color images yielded promising results.

Hardware Description

A field-imaging system was set up during the 2020-21 strawberry growing season at UF Plant Science Research and Education Unit (PSREU) in Citra, FL. A Campbell Scientific 237-L leaf wetness sensor was used as a reference surface to take images and a reference wetness detection point. A FLIR E8 infrared camera with a resolution of 320 x 240 pixels and a WYZE v2 color camera with a resolution of 1920 x 1080 pixels were used to take color and thermal images. Both cameras were connected to a single-board computer (Raspberry Pi 4, Raspberry Pi Foundation, Cambridge, UK) using USB cables. The single-board computer was connected to Verizon MiFi 4G wireless cellular modem to upload images to Google Drive. Those images were downloaded to a local computer for analysis and wetness detection. An imaging system to monitor two strawberry plants was also developed using two WYZE v2 cameras. Fig. 1 shows the system to monitor wetness sensor using the color and infrared camera at UF PSREU, Citra. Fig. 2 shows the system to monitor two strawberry plants, Brilliance and Sensation varieties. The complete block diagram is shown in Fig. 3.

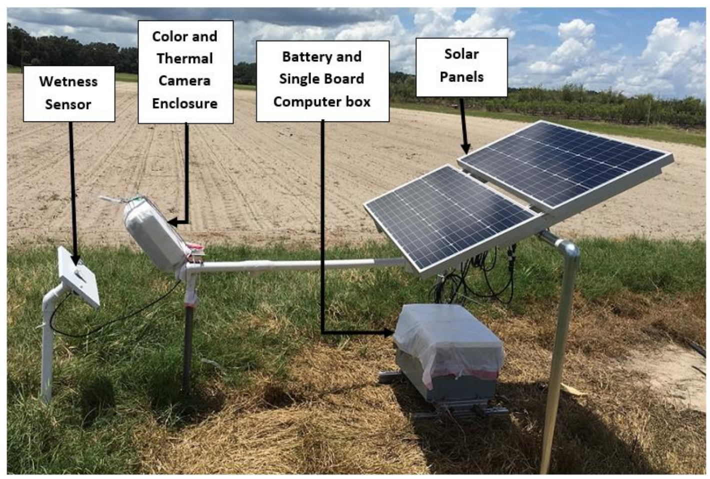

Figure 1. System to monitor wetness sensor using a color and infrared camera at UF PSREU, Citra.

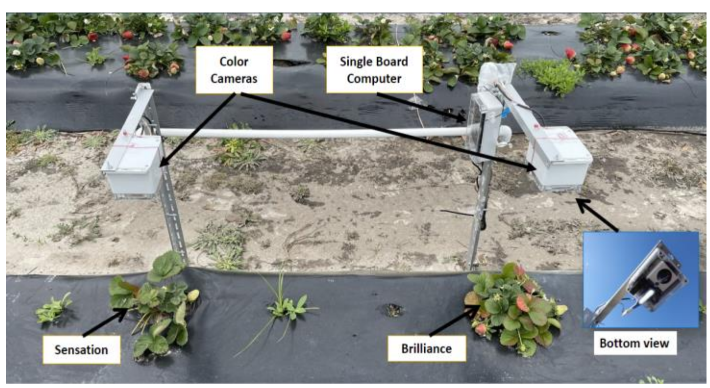

Figure 2. Imaging system to monitor Brilliance and Sensation variety strawberry plants using color cameras at UF PSREU, Citra.

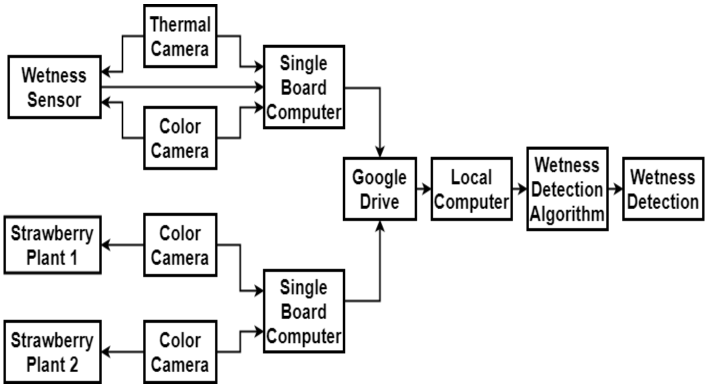

Figure 3. System block diagram

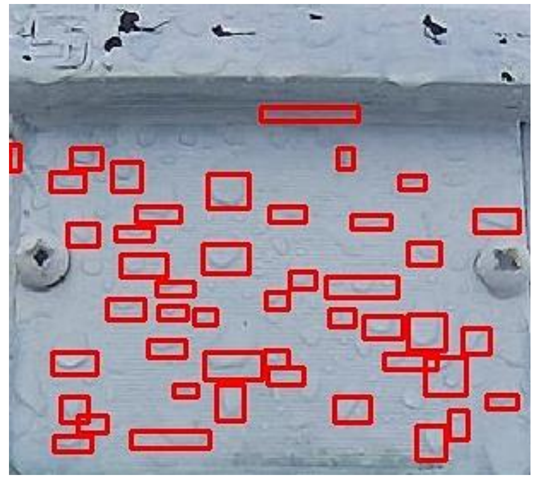

Figure 4. Sample wetness detection using the computer vision method for the color image.

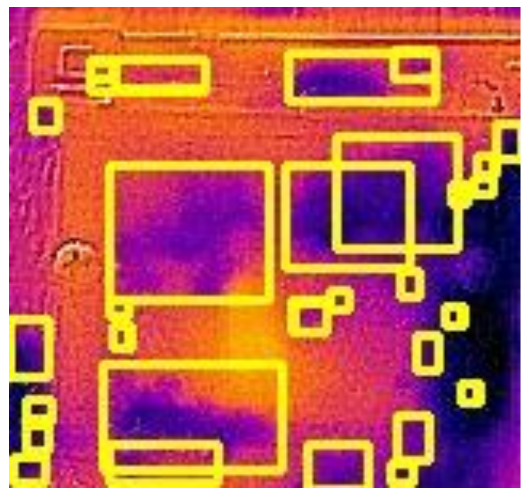

Figure 5. Sample wetness detecting using computer vision method for color image

Methods

The color and thermal images of the wetness sensor were first analyzed using a computer vision method. For each type of image, 100 images were used to calibrate the algorithm, and 1,000 images were used to test the algorithm.

In the second method, three datasets were developed using color and thermal images of the leaf wetness sensor and using strawberry plant images. All images of the datasets were manually labeled into wet/dry class. The datasets were then divided into training and test sets. The training set images were used to train the deep neural network models, and each trained model was tested on the corresponding test dataset.

Results

Wetness detection using computer vision did work well when water droplets were large as shown in Fig 4 and 5, but when water droplets were tiny (< 0.04 inches in diameter), the results were poor. Due to that, a different approach was carried out using a deep learning method, which is one of the artificial intelligence methods.

The deep learning method yielded high accuracy for all three datasets when compared with manual observation labels. But the thermal image of the wetness sensor and strawberry plant image datasets were not highly accurate when results were compared with wetness sensor data. Table 1 shows the accuracy in each case. The results for the color image of the wetness sensor dataset were highly accurate when compared with manual observation, and when compared with wetness sensor data.

In the future, a small device can be made, which takes color images of a reference surface. Using a pre-trained deep learning model, the device can classify an image into wet/dry category, and that results can be used to measure LWD (leaf wetness duration), which is an important parameter in strawberry disease risk prediction.

Table 1. Results from the deep learning method for three datasets.

	Accuracy when compared with manual observation labels	Accuracy when compared with wetness sensor data
Color image of the wetness sensor dataset	0.946	0.862
Thermal image of the wetness sensor dataset	0.950	0.782
Strawberry plant image dataset	0.970	0.781

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